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AIRCRAFT WITH TRIM CONTROL
[LETATELNYY APPARZT S BALANSYRNYM UPRAVLENIYEM]

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AIRCRAFT WITH TRIM CONTROL /1*

Field of technology

This invention pertains to the field of aircraft building and, more specifically, to an aircraft with trim control.

This invention may be used in the development of high-speed light and ultra-light aircraft with trim controls that may be useful in agriculture, acrobatic-sport aviation and as instructional-trainer aircraft.

Previous level of technology

Aircraft with trim controls currently in existence have insufficiently high flying characteristics; for example, there is a problem of range and speed for sports aircraft, one of lift-capability for transport and agricultural aircraft and a problem of controllability (safety) for instructional-trainer aircraft.

Aircraft with trim controls are known (DE, OS, 3637691) that include a flexible shaped wing made of support elements that is secured to a frame containing a longitudinal beam, opposing lateral beams, a mast and steering trapeze connected together by cable bands. Here, the wing has an S-shaped profile and a covering of up to 50% of the length of the profile cord in the upper portion. Each lateral beam is placed between the upper and lower wing coverings inside the profile, which is hinged to the longitudinal beam and has a certain angle of back sweep with the capability for change during operation.

* Numbers in the margin indicate pagination in the foreign text.

(The sweep on the leading edge of the wing is on the order of 25-30°). The leading edge of the wing is formed by a cable band, which is stretched between the nose portion of the longitudinal beam and the end portion of each lateral beam and has the ability to change the length of this cable band during operation of the aircraft. In addition, the wing is built with a geometric twist of its tips by an angle that is smaller than the angle at which the center portion of the wing is set. /2

The aircraft described is built in accordance with the "flying wing" aerodynamic design, which is traditional for aircraft with trim control. This design makes it possible to use a frame structure with a minimal set of elements. This reduces the weight of the wing, makes it possible to carry out assembly of the wing and prepare the aircraft for operation quickly and easily. The back sweep of the wing combined with the negative geometry of the twist in the wing tips will ensure longitudinal stability of the noted aircraft. In addition, this sweep improves the rudder control of the aircraft. The S-shape wing profile makes it possible to reduce the risk of flutter pitchdown during flight with the wings a low angles of attack because of the fact that, with these profiles, there is no shift in the center of pressure when the angle of attack changes. The presence of a covering on two sides of the profile increases the significance of the aerodynamic quality of the wing by reducing the resistance of the profile. This design makes it possible to alter

the tension of the wing covering during operation by changing the length of the cable bindings that form the leading edge of the wing and change the sweep of the lateral beams, which makes it possible to alter the aerodynamic quality and the ability to control the aircraft in flight. As the tension increases, aerodynamic also increases because of the improvement in the profile shape of the wing in areas that are not shaped by the support elements although, in this situation, the ability to control the aircraft and vice versa.

However, the use of the "flying wing" aerodynamic design in the noted aircraft does not make it possible to achieve high values of aerodynamic quality in view of the mandatory presence of the /3 significant wing sweep and negative twist of its tips. In addition, use of the S-shaped wing profile also reduces the aerodynamic quality of the wing. When this occurs, the noted aircraft with this type of aero-dynamic design are prone to flutter pitchdown during flights at low angles of attack, which adversely affects their stability.

An aircraft is known with trim control (SU, A, 891501) that includes a frame formed by a longitudinal beam, two opposing lateral beams with counterweights on the tips, a mast and a control trapeze connected together by means of cable bindings. This aircraft has a flexible wing shaped by means of its support elements whose leading edge is formed by lateral beams, the ends of which are formed by counterweights while the trailing edge is formed by a cable binding stretched between the counterweights and the longitudinal beam. The

wing has a trapezoidal shape in plane and there is no sweep. The wing profile has a covering over the entire length of the chord in the upper portion and covering of up to 60 percent of the chord length in the lower portion. The profile of the wing has a covering in its terminal portions and from the upper and lower sides over the entire length of the wing chord. In addition, the noted aircraft is equipped with a stabilizer mounted ahead of the wing and formed as a flexible non-profiled surfaces whose leading edge is the cable binding, which is stretched between the leading edge of the longitudinal beam and the counterweights on the tips of the lateral beams. This aircraft is also equipped with a fin formed as a flexible non-profiled surfaced stretched between the longitudinal beam and cable binding, which connects the free end of the mast in the aft end of the longitudinal beam.

Use of a stabilizer in the design of the noted aircraft would make it possible to stay away from the "flying wing" aerodynamic design and switch to the "canard" design which will make it possible to achieve higher values of aerodynamic quality by reducing the angle of sweep, the absence of geometric twist in the wing and the ability to utilize a profile with a cover skin on the upper and lower /4 aspects of the profile over the entire length of the chord which will have much higher values of aerodynamic quality.

The use of counterweights mounted on the wing tips in the design of this aircraft makes it possible to reduce inhibiting loads on the

lateral beams and thus also permits and increase in the wing span and, correspondingly, its length while increasing the aerodynamic quality of the aircraft by reducing the inductive resistance of the wing. The presence of a fin makes it possible to retain the capability for rudder control of the aircraft, which is adversely affected when the wing sweep is dropped.

The presence of counterweights increases the weight of the aircraft, however, and their placement on the ends of the lateral beams combined with the increase in wingspan leads to an increase in the wing's moment of inertia in the transverse direction, which makes rudder control of the aircraft substantially more difficult. In this situation, with angles of attack close to zero, the flexible stabilizer is subject to flutter vibrations ("flaps"), which essentially reduces the longitudinal stability of the aircraft during its operation.

In addition, the noted structural design of the frame does not make it possible to extend the wingspan without the use of special equipment such as elastic cords, which pull the wing skin towards the longitudinal beam or to counterweights, which complicates assembly of the wing and its preparation for use.

Here, the noted aircraft design will not make it possible to alter the tension of the wing covering during operation and, as a result, it keeps it from being possible to change the aerodynamic quality and controllability of the aircraft during flight.

Disclosure of the invention

Underlying the invention is the problem of creating an aircraft with trim control and an aerodynamic design and structural implementation of a shaped wing that would make it possible to enhance the aerodynamic quality of the aircraft wing without adversely affecting its stability and controllability while also simplifying the process /5 of assembly and preparing the aircraft for operation.

This problem can be resolved by creating an aircraft with trim control that includes a flexible wing shaped by means of its supporting elements, opposing lateral beams, a mast and steering trapeze connected together by means of cable bands in which the flexible shaped wing based on the invention is made in the form of a wing of the closed type using the "tandem" aerodynamic design with two lifting surfaces that are connected to each other where the first lifting surface is made with a back sweep and the second lifting surface is made with a forward sweep while the opposing lateral beams constitute front and rear pairs in which one end is secured to the nose portion of the wing surface, each lateral beam in the rear pair is secured by its first end to the lower surface of the corresponding lateral beam of the front pair and forms the leading edge of the second lifting surface of the wing.

Use of a wing of the closed type in the "tandem" aerodynamic design on an aircraft with trim control makes it possible to increase wing length without increasing wing span and, in this way, increase

its aerodynamic quality by reducing the inductive resistance of the wing with no increase in the weight of the design. Use of the "tandem" design makes it possible to avoid the risk of flutter pitch-down within a broad range of flight angles of wing attack while controllability does not deteriorate because of the fact that the focal point of the lateral design of this wing is behind the aircraft's center of gravity. Here, the presence of the noted forward and back sweeps of the lifting surfaces increases the aircraft's rudder controllability. In addition, this design makes it possible to use designs with minimal sets of elements, which simplifies manufacture, assembly and preparation of the aircraft for operation and also reduces the weight of the wing. /6

The noted design also makes it possible to reduce the length of the profile chord, which makes it possible to maintain the wing profile shape more precisely, and which, in turn, improves the aerodynamic quality of the wing. Here, the possibility arises of using a wing that has a profile with a higher index of aerodynamic quality, which increases the aerodynamic quality of the wing as a whole.

It is appropriate that each lateral beam of each pair was connected to the longitudinal beam and articulated to the lateral beam of the other pair corresponding to it; here, the lateral beams of the rear pair were connected to the longitudinal beam with the ability to slide together along the axis of the latter.

The hinged fastening of each lateral beam in each pair to the longitudinal beam and to each other and also the ability of the rear pair of lateral beams to slide together along the longitudinal beam makes it possible to carry out simple and fast assembly of the wing and prepare it for operation with simultaneous tensioning of the covering of the front and rear lifting surfaces, which makes it possible to improve the shape of the wing profile at points that are not secured by the profiling elements and will improve the aerodynamic quality of the wing and also change the tension of the wing covering during operation of the aircraft, which makes it possible to alter the aerodynamic quality of the wing and control of the aircraft in flight.

It is desirable that the profiling element made in the form of a rod that forms the end face of the first lifting surface of the wing is secured by one fixed end to the free end of each lateral beam of the front pair while the profiling element, which consists of two rods hinged to each other, is secured to the second end of each lateral beam of the rear pair; the free eng of the first of the rods is hinged to the second end of the corresponding lateral beam of the front pair while the free end of the second rod is hinged to this beam and has the ability to slide along its axis; with this, the second rod forms the end face of the second lift surface of the /7
wing.

The noted structural execution makes it possible to have a profiled wing end face and to produce uniform tension in the flexible covering on both lifting surfaces in a simple manner, which facilitates the process of preparing the wing for operation. Here, the uniform tension of both the upper aspect of the profile and its lower aspect improves the aerodynamic quality of the profile and the wing as a whole while the presence of profiled ends of the lifting surfaces improve stability and aircraft controllability in addition to improving the aerodynamic quality of the wing.

It is fortunate that each free end of the profiling element of each lateral beam in the front pair is connected to the longitudinal beam by means of the cable band which forms the trailing edge of the front lifting surface of the wing and each second rod of the profiling element of each lateral beam of the rear pair is connected to the longitudinal beam by means of a cable band that forms the trailing edge of the wing's lifting surface near the point where it is secured to the first rod.

As a result of this, deflection of the trailing edge of the wing because of the effect of the air current is reduced which contributes to preserving the shape of the wing profile and improves the aerodynamic quality of the wing.

It is advisable that each surface of the flexible shaped wing have a covering on the upper and lower aspects of the wing profile over the entire length of its chord.

This reduces the resistance of the wing profile and the wing as a whole and thereby increases the wing's aerodynamic quality. Here, use of a covering over the entire length of the wing profile chord has become possible because of the use of the "tandem" aerodynamic design in the proposed aircraft, which has a high degree of stability within a broad range of angles of attack.

Thus, creation of the proposed aircraft with trim control /8
makes it possible to achieve much higher values of aerodynamic quality, it incorporates simplicity of design and a high level of operational safety. The closed wing design makes it possible to obtain a wing length that is 2-2.5 times greater along the forward lifting surface and 1.2-1.5 times greater on the rear lifting surface, which leads to an increase in aerodynamic quality since increasing the length will result in a drop in resistance without an increase in structural weight. From the standpoint of aerodynamic design, the "tandem" is well-known and makes it possible not to risk flutter pitchdown at low angles of attack and thus provides an opportunity to use a high-lift profile with a 100 percent double covering. Because of the small size of the lifting surface chords, the support elements ensure more rigid adherence to the profile shape, which also increases aerodynamic quality.

Thus, the proposed aircraft design has a high degree of stability and controllability and also makes it possible to simplify the process of assembly and preparing the aircraft for operation.

Brief description of the drawings

For better under standing of the invention, a concrete example of its execution is given below with references in the drawings that are included where:

Figure 1 schematically depicts an aircraft with trim control built in accordance with the invention, layout view;

Figure 2 schematically depicts an aircraft with trim control built in accordance with the invention, shown in isometry with partial breaks;

Figure 3 is a stress design of the lifting surfaces of the flexible shaped wing built in accordance with the invention.

BEST VARIANT FOR IMPLEMENTATION OF THE INVENTION /9

This aircraft with trim control built in accordance with the invention includes a frame **1** (Figure 1) to which the flexible wing **3**, which is shaped by means of its support elements **2**, is secured. The profile of the wing **3** has a flat-convex shape. The support elements **2** can be made in any design that is known and recommended for analogous purposes and may consist of tubing made of aluminum or plastic bent to the profile of the wing **3**. The wing **3** is made as wing of the closed type in a "tandem" aerodynamic design and has two lifting surfaces **4,5** that are connected to each other. The first front lifting surface **4** has a slight back sweep while the second rear lifting surface **5** has a slight forward sweep. The sweep angles of the front and rear lifting surfaces **4,5** of the wing **3** may be made

approximately equal on the order of 15 -20° (as shown in Figures 1, 2, 3) although these angles may also be made different from each other. The sweep angles here can vary within a range of 5 to 45° and, in any case, the stability and controllability of the aircraft will be assured.

The frame **1** of the wing **3** includes the longitudinal beam **6** and the front and rear pairs of lateral beams **7,8**, lying in opposite directions. Each lateral beam **7** in the front pair is secured with its first end **9** in the nose port **11** of the longitudinal beam **6** by means of a hinge **10** (Figure 2) and forms the leading edge **12** (Figure 3) of the front lifting surface **4** of the wing **3**. Each lateral beam **8** (Figure 2) of the rear pair is secured at its first end **13** by means of a hinge unit **14** in the tail portion **15** of the longitudinal beam **6** with the ability to slide along its longitudinal axis. The unit **14** may be of any known design intended for similar purposes; for example, it can be made as spring-loaded cylindrical element **16** placed coaxially on the longitudinal beam 6 to which hinges **17** secured on the first end **13** of each lateral beam **8** of the rear pair are rigidly affixed on both sides.

The second end **18** of each lateral beam **8** of the rear pair is secured by means of a hinge **19** to the bottom surface of the corresponding lateral beam **7** of the front pair and forms the leading edge **20** (Figure 3) of the rear lifting surface **5** of the wing **3**. The length of each lateral beam **7** (Figure 2) of the front pair to each

lateral beam **8** of the rear pair is in an approximate ratio of 3/2. This ratio will depend on the purpose of the proposed aircraft and can vary from 1/1 to 1/2. The placement of hinges **19** over the length of the lateral beams **7** of the front pair will determine the sweep angle along the leading edges **12,20** (Figure 3), respectively of the front and rear lifting surfaces **4,5** of the wing **3**.

The mast **21** and control trapeze **22** are secured to the longitudinal beam **6** (Figure 2) approximately midway between the point where the hinges **10** of the lateral beams **7** of the front pair and the hinge unit **14** of the lateral beams of the rear pair are fastened. The point where they are affixed will depend on the purpose of the proposed aircraft. Cable bands **23** are drawn tight from the tip of the mast **21** to the lateral beams **7** of the front pair and to the nose and tail portions **11,15** of the longitudinal beam **6**. Cable bands **23** are also drawn tight from the free angles of the control trapeze **22** to the lateral beams **7** of the front pair and to the nose and tail portions **11,15** of the longitudinal beam **6**. These bindings **23** provide geometric invariability to the structure.

The profiling element **25** which consists of a rod shaped in accordance with the wing profile made of aluminum tubing, for example, is secured with one end fixed on the free end **24** (Figure 1) of each lateral beam **7** of the front pair. Each rod **26** forms the corresponding end **27** (Figure 3) of the first lifting surface **4** of the wing **3**.

The profiling element **28**, which consists of two rods **29** joined together by means of a hinge **30** is articulated on the second end **19** (Figure 3) of each lateral beam **8** of the rear pair. Each rod **29** is an aluminum tube, for example, bent according to the profile of the wing **3**. The free end **31** of the first rod **29** is secured by means of the hinge **32** to the second end **18** of the corresponding lateral beam **8** of the rear pair near the point where it is affixed to the corresponding lateral beam **7** of the front pair. The free end **33** of the second rod **29** is connected by means of the hinge unit **34** to the corresponding lateral beam **8** of the rear pair, which has the ability to slide along its longitudinal axis. The hinge unit **34** may be any known design intended for similar purpose; for example, it may be analogous to the hinge unit **14** described above. Here, every second rod **29** forms a corresponding end **35** (Figure 3) of the rear lifting surface **5** of the wing **3**. /11

Each free end **36** (Figure 2) of the rod **26** of the profiling element **28** of each lateral beam **7** of the front pair is connected to the longitudinal beam **6** by means of a cable binding **23**, which forms the trailing edge **37** (Figure 3) of the front lifting surface **4** of the wing **3**. Each second rod **29** (Figure 2) of the profiling element **28** of each lateral beam **8** of the rear pair is connected to the longitudinal beam **6** near the point where it is fastened to the front rod **29**, also by means of the cable binding **23** which forms the trailing edge **38** (Figure 3) of the rear lifting surface **5** of the wing **3**.

The flexible covering **39** which forms the front lifting surface **4** of the wing **3** is stretched onto the contour formed by the lateral beams **7** (Figure 2) of the front pair (leading edge **12**) by the profiling elements **25** (end face **27**) and the cable bindings **23** (trailing edge **37**). The flexible covering **40** that forms the rear lifting surface **5** of the wing **3** is stretched onto the contour formed by the lateral beams **8** of the rear pair (leading edge **20**) by means of the second rods **29** of the profiling elements **28** (end face **35**) and cable bindings **23** (trailing edge **38**). With this profile of the wing **3** on the front and rear lifting surfaces **4,5**, it is possible to have a covering at the top alone or at the top and partially at the bottom although the "tandem" aerodynamic design makes it possible to place the coverings **39,40**, on both the top and bottom of the profile of the wing **3** over the entire length of its chord.

The payload (not shown in drawing) whether a pilot, a motor /12 carriage with one or two pilots, or a container, for example, is suspended on the longitudinal beam **6** near the point where the control trapeze **22** is affixed to it.

All elements of the frame **1** can be made from aluminum tubing; the flexible covering **39,40** can be made of fabric of the Dacron or Kevlar types; the cable bindings **23** can be cable made of steel or synthetic materials. The hinge units **14** and **34** may be spring-loaded by means of spring elements **41** (Figure 3) or made of rubber cords, for example.

Assembly of the aircraft is accomplished as follows.

The lateral beams **7,8** of the front and rear pairs are secured to the longitudinal beam **6** by means of hinges **10** and hinge unit **14**. The profiling elements **25,28** are secured to the lateral beams **7,8** while the cable bindings **23** are affixed to these elements **25,28** and to the longitudinal beam **6**. The lateral beams **7,8** are then joined to the longitudinal beam **6** and the flexible coverings **39,40** are pulled on over the shaped contours. Afterwards, the lateral beams **7,8** are opened and preliminary tensioning of the lifting surfaces **4,5** is done. Then, the profiling element **2** shapes the profile of the wing **3**.

The hinge unit **14** is pulled forcefully in the direction of the nose portion **11** of the longitudinal beam **6** by means of the spring element **41**, which leads to separation of the lateral beams **7,8**. As a result of this, uniform tensioning of the covering **39** on the front lifting surface **4** of the wing **3** and the middle portion of the rear lifting surface **5** of the wing **3** occurs. The hinge units **34** are then drawn forcefully in the direction of the second ends of the lateral beams **8** of the rear pair by means of the spring elements **41** as a result of which, there is uniform tensioning of the covering **40** of the rear lifting surface **5** of the wing **3**.

The direction of force during tensioning of the coverings **39,40** of the wing **3** is indicated by the arrows A in Figure 3.

After suspending the pilot or motor carriage, the aircraft is ready for operation.

Operation of the aircraft is accomplished as follows.

Operation of this aircraft is analogous to operation of any /13 known aircraft with trim control.

Lift force is created by the front and rear lifting surfaces **4,5**; here, in accordance with the "tandem" design, both surfaces **4,5** play an equal role in creating this lifting force. Because of the fact that the "tandem" design makes it possible to have greater length in both lifting surfaces **4,5**, the inductive resistance of the wing **3** as a whole is reduced and, in this way, its aerodynamic quality is also increased. Since the aircraft's center of gravity is between the lifting surfaces **4,5** which create lift, the longitudinal stability and controllability of the aircraft increase in proportion to the increase in distance between the lifting surfaces **4,5** which create lift. At low angles of attack with use of the "tandem" design, there is not "flapping" of the coverings **39,40** which would lead to flutter pitchdown.

Control of the aircraft in flight is carried out by deflection of the center of gravity by the pilot (load) shifting relative to the control trapeze **22**. Since the span of the wing **3** has been reduced in comparison to the prototype, its rudder control will increase. Here, the combination of a slight back sweep of the front lifting surface **4** and slight forward sweep of the rear lifting surface **5** leads to

improvement in control of the aircraft. Since the air load is uniformly distributed between the front and rear lifting surfaces **4,5**, the load on each lateral beam **7,8** of the wing **3** is reduced making it possible to reduce the weight of the frame **1**.

Thanks to the hinged fastening of the lateral beam **7,8** to each other and to the longitudinal beam **6**, the possibility exists for duplicating the tension of the flexible covering **39,40** during operation of the apparatus by changing the tension of the spring element **41** which will make it possible to change the aerodynamic quality of the wing **3** during flight. The sweep angles of the leading edge of [both] lifting surfaces **4,5** of the wing **3** also depend on the tension value of the spring element **41** which will influence the /14 control of the aircraft, which can also change during flight.

Industrial applicability

This invention can be used to develop fast light and ultra-light aircraft with trim control that can be used in agriculture, sports-acrobatic aviation and as instructional-trainer aircraft.

CLAIMS OF THE INVENTION /15

1. This aircraft with trim control which includes a flexible wing (3) shaped by the support elements (2) fastened to a frame (1) which includes a longitudinal beam (6), lateral beams (7,8) lying opposite each other, a mast (21) and control trapeze (22) connected together by cable bindings (23) ***is distinguished by the fact*** that the flexible shaped wing (3) is made as a wing of the closed type using

the "tandem" design and has two supporting surfaces (4,5) that are connected to each other, the forward lifting surface (4) is swept back while the rear lifting surface (5) is swept forward; here, the lateral beams (7,8) that lie opposite each other constitute front and rear pairs, each lateral beam (7) of the front pair is secured by its first end (9) to the nose portion (11) of the longitudinal beam (6) and forms the leading edge (12) of the front lifting surface (4) of the wing (3); each lateral beam (8) of the rear pair is secured by its first end (13) to the tail portion (15) of the longitudinal beam (6) and is fastened by its second end (18) to the lower surface of the corresponding lateral beam (7) of the front pair and forms the leading edge (20) of the rear lifting surface (5) of the wing (3).

2. This aircraft with balance trim in accordance with paragraph 1 ***is distinguished by the fact*** that each lateral beam (7,8) of each pair is hinged to the longitudinal beam (6) and to the lateral beam (8,7) that corresponds to it; in this situation each lateral beam (8) of the rear pair is connected to the longitudinal beam (6) and has the ability to slide jointly along the longitudinal axis of the latter.

3. This aircraft with balance trim in accordance with paragraph 2 ***is distinguished by the fact*** that the profiling element (25) which is made in the form of a rod (26) that forms the corresponding end (27) of the front lifting surface (4) of the wing (3) is secured with

one end fixed to the free end (24) of each lateral beam (7) of the front pair while the profiling element (28) which consists of two rods hinged to each other is hinged to the second end (19) of each lateral beam (8) of the rear pair, the free end (31) of the first of these is hinged to the second end (18) of the corresponding lateral beam (8) of the rear pair near the point where it is fastened to the corresponding lateral beam (7) of the front pair while the free end (34) of the second rod (29) is hinged to this beam (8) with the ability to slide along its longitudinal axis while the second rod (29) forms the end (35) of the rear lifting surface (5) of the wing (3). /16

4. This aircraft with balance trim in accordance with paragraph 3 ***is distinguished by the fact*** that each free end (36) of the rod (26) of the profiling element (28) of each lateral beam (7) of the front pair is connected to the longitudinal beam (6) by means of a cable binding (23) that forms the trailing edge (37) of the front lifting surface (4) of the wing (3), each second rod (29) of the profiling element (28) of each lateral beam (8) of the rear pair is connected to the longitudinal beam (6) near the point where it is fastened to the first rod (29) by means of a cable binding (23) that forms the trailing edge (38) of the rear lifting surface (5) of the wing (3).

5. This aircraft with balance trim in accordance with the preceding paragraphs ***is distinguished by the fact*** that each lifting

surface (4,5) of the flexible shaped wing (3) has coverings (39, 40) on the upper and lower aspects of the profile of the wind (3) over the entire length of its chord.

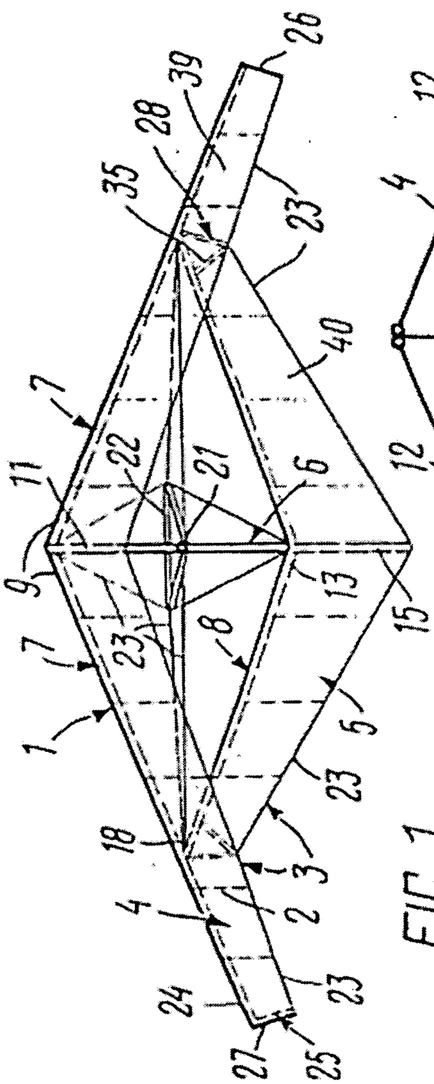
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FIG. 1

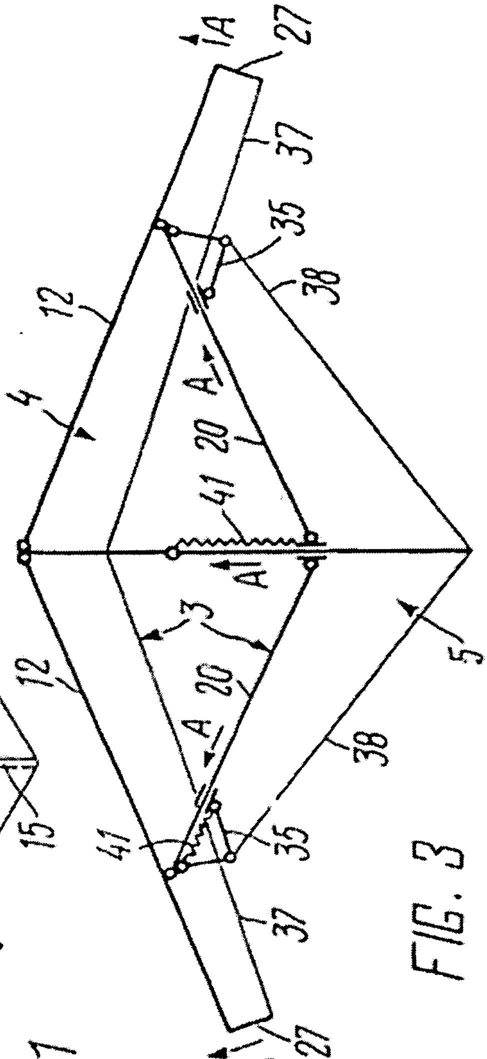
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FIG. 3

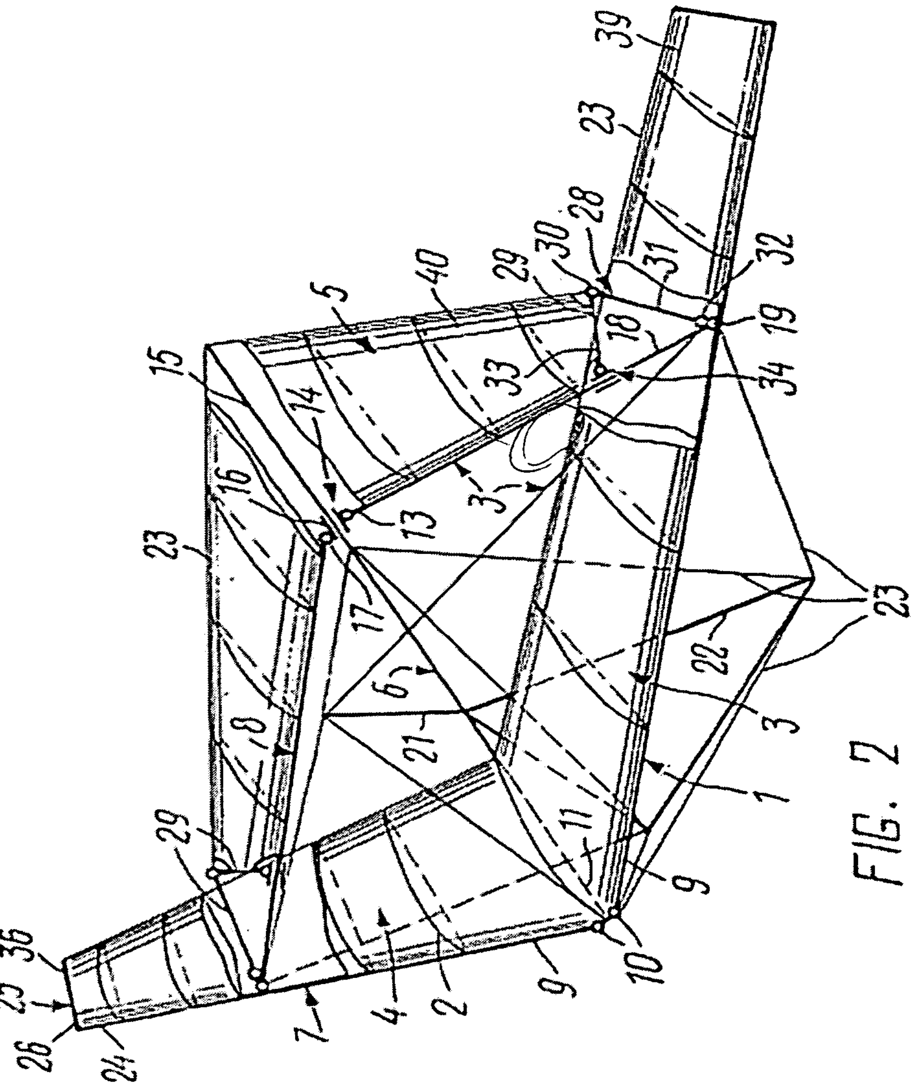

FIG. 2